Remarks

Reconsideration of this Application is respectfully requested.

Upon entry of the foregoing amendment, claims 1-15, 17-20 and 22-25 are pending in the application, with claims 1 and 24 being the independent claims. Claims 16 and 21 are sought to be cancelled without prejudice to or disclaimer of the subject matter therein. Applicants reserve the right to file divisional applications to the canceled subject matter. Claims 1 and 9 are sought to be amended. New claims 22-25 are sought to be added. These changes are believed to introduce no new matter, and their entry is respectfully requested.

Based on the above amendment and the following remarks, Applicants respectfully request that the Examiner reconsider all outstanding objections and rejections and that they be withdrawn.

Election of Invention

Applicants hereby affirm the election of Group I (claims 1-20; drawn to a method of producing a capacitor electrode) for prosecution in the present application. Claim 21 has been canceled herein without prejudice or disclaimer of the subject matter therein. Applicants reserve the right to file divisional applications to the non-elected subject matter. This election is made without traverse.

Objection to the Specification

The specification has been objected to as failing to provide proper antecedent basis for the claimed subject matter. *See* Office Action, page 3, lines 16-22. Paragraph [0042], which bridges pages 10 and 11, has been amended to satisfy the examiner's request. Support for the amendment can be found in original claims 7-11 of the application as filed. This amendment is believed to introduce no new matter and entry thereof is respectfully requested. Applicants submit the rejection is now moot and request that it be withdrawn.

Rejections under 35 U.S.C. § 112

Claims 7-11 have been rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as their invention. *See* Office Action, page 4, line 8, through page 5, line 3).

Applicants have amended the specification, as discussed above, to include the subject matter disclosed in claims 7-11 as originally filed. The specification now fully supports claims 7-11. Applicants submit the rejection is now moot and request that it be withdrawn.

Rejections under 35 U.S.C. § 102

Claims 1, 3, 4, 6, 16, 17 and 19 have been rejected under 35 U.S.C. § 102(b) as being anticipated by Japanese Unexamined Patent Application Publication 59-083772-A

(the '772 application). *See* Office Action, page 5, line 11, through page 6, line 7. Applicants respectfully traverse the rejection.

To facilitate Applicants' analysis of this rejection and of the '772 application, Applicants had a translation of the '772 application prepared by TransPerfect Translations, 601 Thirteenth Street, NW, Suite 320 North, Washington, DC 20005. A copy of the translation is enclosed with this reply for the Examiner's information and convenience. Please note that, while Applicants have no reason to question the accuracy of this translation, the translation is NOT a verified translation. To the extent that the Examiner would have a question concerning the accuracy of any portion of the translation, the Examiner is invited to obtain independent confirmation of same. Furthermore, in the event that the accuracy of any portion of the translation becomes an issue in any proceeding in the future, Applicants reserve the right to obtain a separate verified translation of same.

The Examiner argues that the '772 application "discloses a method of manufacturing an electrode foil for a capacitor, comprising forming a pattern of fine lines (1) on the foil surface (2) with a laser beam, and then etching the foil." Office Action, page 5, line 11-16. However, unlike the claimed invention, the '772 application appears only to teach applying a laser to a foil in parallel straight lines, or with an X-shape. In contrast, Applicants have determined that a parallel wave or intersecting wave pattern is preferred for improving the strength of the etched foil. See Examples 3 and 4 on pages 14 and 15 of the application as filed. Accordingly, claim 1 has been amended to specifically recite applying a laser to a foil create a wave pattern on the foil. Further, new claims 22 and 23 have been added to the application to recite a parallel wave pattern and an intersecting wave pattern, respectively. A wave pattern is distinct from the pattern of lines disclosed in the '772 application. For at least this reason, claim 1 and

claims 3, 4, 6, 17 and 19, which depend from claim 1, are patentable and Applicants respectfully request that the rejection of claims 1, 3, 4, 6, 16, 17 and 19 be withdrawn.

Rejections under 35 U.S.C. § 103

Claims 1, 2 and 5 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over the English language abstract of Japanese Unexamined Patent Application Publication 02-075155-A (the '155 abstract) in view of U.S. Patent No. 6,426,864 to O'Phelan *et al.* ("the '864 patent). *See* Office Action, page 6, line 16, through page 7, line 9. Applicants respectfully traverse the rejection. The '155 abstract, alone or in combination with O'Phelan, does not provide motivation or suggestion for the claimed invention.

To establish a *prima facie* case of obviousness the references, alone, or in combination, must teach or suggest all claim limitations. M.P.E.P. § 2142. Where prior art references require a selective combination to render obvious a claimed invention, there must be some reason for the combination other than hindsight gleaned from the invention disclosure. *Interconnect Planning Corp. v. Feil*, 774 F.2d 1132, 1143, 227 U.S.P.Q. 543, 551 (Fed. Cir. 1985).

The Examiner indicates that the '155 abstract does not teach etching of an electrode foil, however, the Examiner argues that the '155 abstract discloses "that a laser can be applied to a porous electrode foil to heat the foil and thereby form a pattern" and that O'Phelan discloses "a method of etching an electrode foil to form a porous structure." Office Action, page 6, line 19-20. However, neither the '155 abstract nor O'Phelan, alone or in combination, provide motivation or suggestion for applying a laser to a foil to "create a pattern on the foil." The '155 abstract appears to disclose using a

laser to cut a substance into a particular shape and O'Phelan appears to disclose applying a laser to cut holes through a foil.

As discussed above, the present invention is directed to a method for producing an electrode for a capacitor from a foil by applying a laser beam to a portion of the foil to create a pattern on the foil. Claim 1 has been amended to specifically recite applying a laser to a foil to create a wave pattern on the foil. Because both the '155 application and O'Phelan, whether alone or in combination, teach the use of a laser to cut through a foil, it would not have been obvious, absent impermissible hindsight gleaned from Applicants' invention disclosure, to one skilled in the art at the time of the invention, in view of O'Phelan and the '155 application, to apply a laser to create a pattern on the surface of a foil as recited in amended claim 1. Furthermore, there is no motivation or suggestion in either reference for creating a wave pattern on the surface of a foil as recited in amended claim 1. For at least these reasons, independent claim 1 and claims 2 and 5, which depend therefrom, are patentable and Applicants request allowance of same.

Claims 7-11 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over the '772 application in view of U.S. Patent No. 5,715,133 to Harrington *et al.* ("the '133 patent"). (Office Action, page 8, lines 14-18).

Claim 18 has been rejected under 35 U.S.C. § 103(a) as unpatentable over the '772 application in view of U.S. Patent No. 3,779,877 to Alwitt ("the '877 patent"). (Office Action, page 9, lines 7-10).

Claim 20 has been rejected under 35 U.S.C. § 103(a) as unpatentable over the '772 application in view of U.S. Patent No. 4,481,084 to Chen *et al.* ("the '084 patent") and "A New Coating Process for Aluminum" by Patel *et al.* ("the Patel reference") (Office Action, page 10, lines 3-15).

Claims 7-11, 18 and 20 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over the '772 application in view of U.S. Patent No. 6,802,954 to Hemphill *et al.* ("the '954 patent").(Office Action, page 11, lines 12-17). (Office Action, page 12, lines 1-4). (Office Action, page 12, lines 14-19).

Claim12 has been rejected under 35 U.S.C. § 103(a) as being unpatentable over the '772 application in view of the English language abstract of Japanese Unexamined Patent Application Publication 07-049428-A ("the '428 abstract"). (Office Action, page 13, lines 7-10).

Claims 13 and 14 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over the'772 application in view of the '428 Abstract (Constitution) ("the '428 abstract") as applied to claim 12, above, and further in view of U.S. Patent Application Publication 2002/0111029 to Johnson ("Johnson "). (Office Action, page 13, line 21, through page 14, line 4).

Claim 15 has been rejected under 35 U.S.C. § 103(a) as being unpatentable over the '772 application. (Office Action, page 14, lines 13-17).

Applicants respectfully traverse the above rejections.

As discussed above, unlike the claimed invention, the '772 application appears only to teach applying a laser to a foil in straight parallel lines, or with an X-shape. In contrast, Applicants have determined that a parallel wave or intersecting wave pattern is preferred for improving the strength of the etched foil. See Examples 3 and 4 on pages 14 and 15 of the application as filed. Accordingly, claim 1 has been amended to specifically recite applying a laser to a foil create a wave pattern on the foil. A wave pattern is distinct from the pattern of lines disclosed in the '772 application. Further, none of the cited references provide motivation or suggestion, absent impermissible hindsight gleaned from Applicants' invention disclosure, to modify the teaching of the

'772 application to replace the straight parallel line patterns with a wave pattern as claimed. The mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification. *In re Fritch*, 972 F.2d 1260, 1266, 23 U.S.P.Q.2d 1780, 1783-84 (Fed. Cir. 1992).

For at least this reason, independent claim 1 and claims 7-15 and 18-20, which depend from claim 1, are patentable and Applicants respectfully request that the rejection of claims 1, 7-15 and 18-20 be withdrawn.

New Claims 24 and 25

New independent claim 24 is directed to a method in which a laser is applied to the foil to create a pattern after the etching step. As disclosed at page 11 of the application as filed, in one embodiment of the present invention, a foil is first etched and then a pattern is applied to the etched foil using a laser, such that the pattern in the foil forms areas of strength to prevent propagation of cracks. None of the cited references provide motivation or suggestion for a process in which a laser is applied to the foil to create a pattern after the etching step. For at least this reason, new independent claim 24 and claim 25, which depends therefrom, are patentable and their allowance is respectfully requested.

Conclusion

All of the stated grounds of objection and rejection have been properly traversed, accommodated, or rendered moot. Applicants therefore respectfully request that the Examiner reconsider all presently outstanding objections and rejections and that they be withdrawn. Applicants believe that a full and complete reply has been made to the

outstanding Office Action and, as such, the present application is in condition for allowance. If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at the number provided.

Prompt and favorable consideration of this Amendment and Reply is respectfully requested.

Respectfully submitted,

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(54) ETCHING METHOD FOR ALUMINUM FOIL

(21) Application Number S57-192390
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SPECIFICATIONS

1. Title of the Invention

ETCHING METHOD FOR ALUMINUM FOIL

2. Scope of the Patent Claims

(1) An etching method for aluminum foil wherein multiple fine lines to resist corrosion are created on the surface of the aluminum foil, and wherein an etching process is performed.

(2) An etching method for aluminum foil as claimed in Claim 1, wherein the fine lines are formed in parallel to the rolling direction of the aluminum foil.

(3) An etching method for aluminum foil as claimed in Claim 1, wherein the fine lines are formed in a diagonal shape in relation to the rolling direction of the aluminum foil.

(4) An etching method for aluminum foil as claimed in Claims 1, 2 or 3, wherein the fine lines are formed on one side of the aluminum foil.

(5) An etching method for aluminum foil as claimed in Claims 1, 2 or 3, wherein the fine lines are formed on both sides of the aluminum foil.

3. Detailed Explanation of the Invention

The present invention relates to an etching method for aluminum foil that has superior tensile strength as well as bending strength, and wherein it is possible to obtain an etching foil that can avoid problems such as breaking in the rolling process of condenser elements.

As is widely known, the aluminum foil that is used in the electrodes of electrolysis condensers undergoes an etching process to corrode the surface in order to increase the surface area.

However, after the etching process, the mechanical strength of the aluminum foil such as its tensile strength and bending strength may be reduced due to corrosion, and so in the case of using an automatic wrapping device to wrap the condenser element, there can be problems such as breaking of the attachment part of the terminal or of the wrapping part. Therefore, regardless of the method used for etching, many researchers have struggled to obtain a large surface area without damaging the mechanical strength of the thin aluminum foil.

Considering these points, as the result of a variety of research by the present inventors, we have succeeded in developing an etching method that can easily obtain an etching foil with superior mechanical strength without reducing the surface area, and here, we will propose this etching method wherein the

etching method is performed after multiple fine lines on the surface of the aluminum foil to resist corrosion.

In other words, by creating multiple fine lines to delay the initiation of galling in resistance to corrosion on either one or on both surfaces of the aluminum foil to be etched, along with forming a corrosion surface that has multiple deep irregularities with a large amount of fusion in parts where the fine lines have not been formed, it is possible to also form a corrosion surface with multiple shallow irregularities with a small amount of fusion or with no fusion in the parts where the fine lines have been formed, making it possible to obtain an etching foil with superior mechanical properties without losing any surface area overall.

There is a variety of methods to create fine lines to resist corrosion, the simplest of which is the printing method, wherein the majority of the printing ink has low wettability in relation to the corrosion solution, thereby delaying the advance of corrosion, so this method is the most effective in the example of embodiment of the present invention. There are also methods to create oxidation fine lines through heating using a laser light, or methods to create the fine lines through pressurization using a roller, and in the former, the oxides generated through the heat can resist corrosion, whereas in the latter, the deformation of the aluminum structure resulting from the pressure deformation can resist corrosion. Further, the fine lines that resist this corrosion act as a supplementary foil in leaving the parts with the higher strength on the etching foil, and as a result, after etching, the aluminum foil has superior mechanical strength.

The width, spacing and arrangement status of the fine lines can be appropriately selected in relation to the set-up of the surface area and the mechanical strength, and Figure 1 shows the case wherein multiple fine lines (2) are formed in parallel to the rolling direction (the longitudinal direction) of the aluminum foil (1). In this structure, as the electrode foil wrapped about the conventional condenser element has been cut with a slit of a given width in parallel to the rolling direction such that the tensile strength in the rolling direction and the bending strength in the rolling direction and in the perpendicular direction would be increased, it is the most preferable embodiment of the structure forming fine lines on the aluminum foil. Figure 2 shows the case wherein multiple fine lines (2) are formed in a diagonal form on the aluminum foil (1), and Figure 3 shows the case wherein multiple fine lines (2) are formed to intersect in an X-shape on the aluminum foil (1). In both of these structures, the effect is to have superior tensile strength as well as bending strength. Further, Figure 4 shows the structure wherein multiple fine lines (2) are formed in the rolling direction and in the perpendicular direction in parallel, and in this structure, the effect is to obtain an electrode foil by cutting the aluminum foil (1) in the rolling direction and in the perpendicular direction at a given width.

Figures 5(a) and (b) show exploded views of the aluminum foil after etching. Figure 5(a) shows the case wherein the fine lines (2) are formed on only one side of the aluminum foil (1), and Figure 5(b) shows the case wherein the fine lines (2) are formed on both sides of the aluminum foil (1).

Here, by forming fine lines to resist corrosion, it might appear that the surface area of the aluminum obtained when said fine lines are not formed could be degraded, but according to the results of experiments, we determined that there is almost no generation of any difference in the condenser capacitance ratio. The reason for this is that the ratio of the fine line part is sufficient at several percent of the overall area, and that it is possible to compensate for the corrosion fusion amount lost by the fine line parts using the other parts wherein there are no fine lines. Also, when the corrosion fusion amount of the aluminum when creating the fine lines is the same as when there are no fine lines, the average cross-sectional area of the part remaining that has not been corroded will be approximately equal, making one think that there might be some difference in the mechanical strength, but according to actual experiments, we determined that there is no significant difference generated in the mechanical strength. The reason for this is thought to be that the corrosion of the parts where there are no fine lines is deep, and so these parts are easily damaged, resulting in low strength for a given unit area, but in the fine line areas, as the corrosion is shallow, the foil will be reinforced, leading to a larger strength for a given unit area.

Next, we will explain the examples of embodiment.

Sample 1

Performing an etching process through an electrolysis etching method by placing an aluminum foil of thickness 100 μ, of purity 99.99% and that has been annealed within a chloride salt solution, and controlling the solution reduction amount such that it

is approximately 38%, we then performed a washing process, and created a 375V product within a boric acid solution.

Sample 2

Using Sample 1, we formed fine lines with magic ink at a spacing of 2.5 mm and a width of 0.25 mm prior to performing the etching process in parallel in the rolling direction of the aluminum foil.

Sample 3

Using Sample 2, we formed fine lines on both sides.

In the present example of embodiment, we sought the equivalent value row capacitance by performing measurements through a bridge circuit within the electrolysis solution, and subtracting the area (cd) from that value, we calculated the μF/cd. Also, for the measurement of the tensile strength, we applied a tensile force on the rolling direction of the etching foil that had been cut with a slit of length 10 cm and width 1 cm, and seeking the Kg value when the foil broke while increasing the tensile force at a rate of 0.25 Kg/second, we calculated the tensile strength Kg/cm. Further, for the bending strength, we bent a sample equivalent to the sample used for the above tensile strength measurement at a 45 degree angle in relation to the longitudinal direction, and taking the bent surface to be the 1 [cm] curvature radius, we applied a tensile force of 250 g to the longitudinal direction. Returning the bent part from the 45 degree bent state to its original position, we then bent it at an angle of 45 degrees in the opposite direction, and performing the operation of returning it to the original state again as a single step, we sought the number of times that the operation could be performed before the bent part broke. The results are as follows:

Note	Capacitance μF/cd	Tensile Strength Kg/cm	Bending Strength
Sample 1	0.72	1.2	3
Sample 2	0.72	1.5	10
Sample 3	0.71	1.8	19

As is clear from the above experimental results, according to the present invention, the capacitance is approximately equivalent in comparison to the conventional etching foil, but the resultant mechanical strength is extremely large, and as the improvement in the bending strength is significant, the present invention can be understood to be exceedingly useful in handling operations or wrapping operations of condenser elements using automatic wrapping devices.

According to the results of these experiments, it is clear that the method to create fine lines through the above described printing method is the most easily implemented, and we discovered that regardless of whether the printing ink that is used in this case is water-based or oil-based, sufficient efficacy can be obtained. The inventors of the present invention initially contemplated the necessity of creating fine lines on the aluminum foil by applying a thick layer of ink that has strong corrosion resistance, but according to the results of the experiments, we obtained sufficient efficacy in fine lines created in a thin layer using ink with exceedingly weak corrosion resistance. The reason for this is that the advance of the corrosion is initially gradual, and then the advance accelerates rapidly, so prior to the basic advance of corrosion on the fine line areas created using the ink, the corrosion of the parts where there are no fine lines will end.

4. Brief Explanation of the Figures

Figures 1 through 4 are partial planar figures of the etching foil in the example of embodiment of the present invention. Figure 5 is an exploded cross-sectional diagram of the etching foil.

Within the Figures, (1) is the aluminum foil, and (2) are the fine lines.

Patent Applicant Japan Capacitor Industrial Co., Ltd.
Representative, Attorney Toshiharu Ōuchi
[illegible seal]

[see source for figures]

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5